REMARKS

In the Office Action, the examiner rejected Claims 1-3, 5, 6, 8, 17-18, 21-24, 34 and 36 under 35 U.S.C. 103(a) as being unpatentable over Gutnik et al. (U.S. Patent No. 6,661,860) in view of Dalal et al. (U.S. Patent No. 6,661,836). The examiner rejected Claims 4, 19 and 20 under 35 U.S.C. 103(a) as being unpatentable over Gutnik et al. (U.S. Patent No. 6,661,860) in view of Dalal et al. (U.S. Patent No. 6,661,836) and further in view of Voorakaranam et al. (Proceedings of 43rd IEEE Midwest Symposium on Circuits and Systems). The examiner rejected Claims 7, 13, 14 and 32 under 35 U.S.C. 103(a) as being unpatentable over Gutnik et al. (U.S. Patent No. 6,661,860) in view of Dalal et al. (U.S. Patent No. 6,661,836) and further in view of Godard (U.S. Patent No. 4,654,861). The examiner rejected Claims 34-37 under 35 U.S.C. 103(a) as being unpatentable over Gutnik et al. (U.S. Patent No. 6,661,860) in view of Dalal et al. (U.S. Patent No. 6,661,836) and further in view of Godard (U.S. Patent No. 4,654,861).

Accordingly, the applicant has amended Claims 1, 17, 34 and 36 to more clearly distinguish the features of the present invention from the technologies disclosed by the cited references. More specifically, the applicant has added the new limitation that the (1) the clock signals under test have pulse waveforms, and (2) the probability estimator estimates the generation probability of the peak-to-peak value based on RMS (root mean square) values of the clock signals under test obtained by the clock skew estimator by

applying ratios between the peak-to-peak value and the RMS values determined by the Rayleigh distribution. The feature (1) is supported by Figure 2B and 3 and the corresponding descriptions int he specification. The clock signals under test shown in Figures 2B and 3 have pulse waveforms rather than sinusoidal waveforms. The feature (2) is supported by Figures 13 and 14 showing the ratios (ex. Zpp/σ) between the peak-to-peak values and the RMS (root mean square) values of clock skews determined by the Rayleigh distribution. With reference to Figures 12 and 13, this feature is supported by the description, for example, from page 21, line 20 to page 22, line 2, which reads as follows:

> As explained above, by the existence of the random components $T^{j,k}_{RS}$ of the clock skew and that the random components $T^{j,k}_{RS}$ being subject to the Gaussian distribution, the peak value collection $\{Z_p\} = \{\max(T^{j,k}_{RS}[n])\}$ of the random components of the <u>clock skew becomes subject to the Rayleigh distribution</u>. The Rayleigh distribution is described on pages 30-31 of S. M. Kay "*Fundamentals of Statistical Signal Processing: Detection Theory*", published by Prentice-Hall, Inc. in 1998.

This feature is also supported by the description and page 23, lines 13-29, with reference to Figure 14, which reads as follows:

> In Figure 14, the samples and peak-to-peak values are plotted for the clock skews between the two signals under test, which have been distributed within the microprocessor. The upper diagram shows the test results in the quiet mode in the microprocessor, and the lower diagram shows the test results in the noise mode. The theoretical curve in the diagrams are calculated from the inverse probability $P_r(Z_{pp}>Z_{pp})$ expressed by the equation (38). <u>The test data complies very well with the theoretical curves of the Rayleigh distribution</u> (especially in the noise mode).

Namely, with use of the equation 38, the present invention estimates the peak-to-peak values in the clock skews among the clock signals under test with use of the statistical analysis, especially, the Rayleigh distribution and the RMS values of the clock skews. Figure 14 shows the correctness of the estimated results of the generation probability of the peak-to-peak value in the present invention by comparing with the actually measured results. In Figure 14, the estimated results are represented by the solid lines and the measured results are represented by the small circles.

The cited Gutnik et al. reference is completely silent about such a statistical relationship between the RMS value of the clock skews and the peak-to-peak value of the clock skew let alone the specific distribution function, i.e., the Rayleigh distribution of the present invention. The cited Gutnik et al. reference discloses, as shown in Figure 1, a digital circuit which includes a plurality of arbiters, each arbiter having first and second input ports and an output port providing an output signal. Each first input of the plurality of arbiters is connected to a first common line and each second input of the plurality of arbiters is connected to a second common line. The output signal of each arbiter will transition to a first state if a first input signal is high and a second input signal is low. The digital circuit further includes a decision circuit, having a plurality of inputs and an output. Each of the inputs of the decision circuit is connected to

a corresponding output of one of the plurality of arbiters. The decision circuit output provides a signal indicative of the time difference between a signal fed to the first common line and a signal fed to the second common line.

In the cited Gutnik et al. reference, with such an arrangement noted above, the difference in arrival times can be measured between digital signal edges of two pulses based on the generation probability of 50% for logic 1 and logic 0. Based on the difference between the minimum value and the maximum value of the arrival times, the digital circuit obtains the peak-to-peak value of the signals supplied to the common lines. In other words, the digital circuit in the cited Gutnik et al. reference has to actually measure the peak-to-peak values by measuring the minimum value (one peak) and the maximum value (another peak). This is more clearly evidenced by the descriptions at column 6, lines 43-60 which reads as follows:

> As the pulse transitions form a low to a high, the center of the slope is typically referred to as the crossover point. Consider an arbiter to which two signals are repeatably applied. A perfectly balanced arbiter would output a1 in half of the trials and a0 in the other half of the trials when inputs to the arbiter are exactly simultaneous. If one input is leading, the fraction of the trials in which the arbiter outputs a1 goes up. If the other input is leading, the fraction of the trials in which the arbiter outputs a0 goes up. The "crossover point," where probability of a1 output equals the probability of a0 output, can be said to be at 0 offset in this case. A real arbiter would have some imbalance. For example, when the inputs are simultaneous, it might output a1 in 2/3 of the trials, and a0 in the other 1/3 of the trials. It might output a1 in half the trials and a0 in the other half of the trials if the one input signal is 10 picoseconds later than the other. In that

> case, the arbiter may be said to have a crossover point of 10 picoseconds. (If the signals were reversed, it would have a crossover point of -10 picoseconds).

As described in the above quote, based on the probability of logic 1 and logic 0 from the outputs of the arbiters which are assigned with predetermined crossover times, the digital circuit obtains the jitter (time difference between two edges) of the signals under test. Further, in the cited Gutnik et al. reference, as described at column 10, lines 25-38, the peak-to-peak jitter is obtained by the difference between the minimum and maximum measured time differences (jitter), which reads as follows:

> Jitter is the temporal variation in time difference between two edges. Jitter at a single node may be determined by iteratively comparing the difference between the edges of the clock at that node and the clock supplied by a reference clock. More generally, the jitter between any two clocks, either both in the system under test or one in the system under test and one external reference, may be computed by repeatedly measuring the time difference between rising edges of the two clocks, and tabulating the results. The peak-to-peak jitter is the difference between the minimum and maximum measured time differences. Thus, the information provided by the output signals of the arbiters are utilized to characterize the jitter of a circuit from which the clock signal originated.

Thus, the cited Gutnik et al. reference does not show any idea of measuring an RMS value of the clock skews and is completely silent about the statistical relationship between the RMS value of the clock skews and the peak-to-peak value of the clock skew. In the present invention, however, the probability estimating apparatus and method estimates the generation probability of the peak-to-peak values of the clock skews without actually measuring

the peak-to-peak values of the clock skews but with use of the measured RMS values of the clock skews based on the ratios therebetween which correspond to the Rayleigh distribution function as shown in Figures 13 and 14. Thus, the principle of operation is fundamentally different from that of the cited Gutnik et al. reference. The applicant has clarified this difference by the amendment made in Claims 1, 17, 34 and 36 as noted above by the feature (2). Thus, the cited Gutnik et al. reference does not show the feature (2) of the present invention.

The cited Dalal et al. reference (U.S. Patent No. 6,661,836) is directed to the jitter measurement technology to obtain an RMS (root mean square) jitter of the signal. In the jitter measuring method of the cited Dalal et al. reference, it first calculates the RMS jitter by producing samples through binary (signal edge states) measurement, determines the probability $P\{x(t)\}$ of the signal edge states, determines edge probability density $fx(t)$ as a function of time by differentiating the probability $P\{x(t)\}$ with respect to time, and estimates the RMS jitter (standard deviation) of the edge transition from $fx(t)$. As noted above, the cited Dalal et al. reference shows the idea of estimating the RMS jitter of the signals but does not show the idea of estimating the probability of peak-to-peak jitter of the clock skew. Thus, the cited Dalal et al. reference is completely silent about the statistical relationship between the RMS value of the clock skews and the peak-

to-peak value of the clock skew. Thus, the cited Dalal et al. reference does not show the feature (2) of the present invention.

The cited Godard reference (U.S. Patent No. 4,654,861) is directed to a jitter measuring method for measuring jitters of receiving signals. As stated in the abstract of the disclosure, the signals under test are sinusoidal test signals. In the present invention, however, the clock signals are in the pulse waveforms. Therefore, the essential feature (1) of the present invention is not shown or suggested by the cited Godard reference.

As discussed above, since the essential features of the present invention are not disclosed by the cited references, and therefore, the present invention is not obvious over the cited references taken singly or in combination.

In view of the foregoing, the applicant believes that Claims 1-37 are in condition for allowance, and the applicant respectfully requests that the application be allowed and passed to issue.

Respectfully submitted,

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